A new evolutionary scenario for the formation of close massive black hole binaries such as M33 X-7

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The formation of close massive black-hole binaries poses a puzzle to binary evolutionary models, especially the intriguing system M33 X-7 (Orosz et al. 2007) which harbours one of the most massive stellar-mass black holes (16 solar masses) orbiting a 70 solar mass O-star every 3.5 days. In standard binary evolution theory an episode of mass transfer or common envelope is inevitable in a binary with such a small orbital period, which would prohibit the formation of a black hole with such a high mass. We argue that a new binary evolution channel, in which rotational mixing plays an important role (referred to as "Case M" in De Mink et al., 2008) can explain the formation of this system.

We find that in very massive close binaries, the tides force the rotation rate of stars to be so high that rotationally induced mixing becomes very efficient. The stars evolve almost chemically homogeneously. Instead of expanding during their main-sequence evolution (with the inevitable consequence of mass transfer), these star stay compact, inside their Roche lobe. Gradually, they evolve into massive helium stars. This scenario naturally leads to the formation of very massive black holes in a very close orbit with a less evolved massive companion such as M33 X-7.